5. WORK PLAN AND METHODOLOGY

5.1 Methodology

ANFIS is a fuzzy inference system implemented in the frame work of adaptive networks. Using a given input/output data set, the ANFIS method constructs a fuzzy inference system (FIS) whose membership function parameters are tuned (adjusted) using a back propagation gradient descent and a least-squares type of method. This allows fuzzy systems to learn from the data they are modelling. FIS structure is a network-type structure, which maps inputs through input membership functions and associated parameters, and then through output membership functions and associated parameters to outputs. ANFIS applies two techniques in updating parameters. For premise parameters that define membership functions, ANFIS employs gradient descent to fine-tune them. For consequent parameters that define the coefficients of each output equations, ANFIS uses the least-squares method to identify them. This approach is thus called hybrid learning method since it combines the gradient descent method and the least-squares method. ANFIS modelling process starts by obtaining a data set (input–output data pairs) and dividing it into training and testing data sets. The training data set is used to find the initial premise parameters for the membership functions by equally spacing each of the membership functions. A threshold value for the error between the actual and desired output is determined. The consequent parameters are found using the least-squares method. Then an error for each data pair is found. If this error is larger than the threshold value, update the premise parameters using the gradient decent method. The process is terminated when the error becomes less than the threshold value. Then the testing data set is used to compare the model with actual system. A lower threshold value is used if the model does not represent the system.

The adaptive network in the proposed fuzzy inference system was feed forward type. The membership function was Sugeno type bell shape, triangular shape and trapezoidal membership function. There were three input membership function for each input and 27 learning rules as shown in figure 1. The learning weight was set to 1 with linear input / output values and for the defuzzification that is to produce crisp output of the consequent part weighted average scheme will be used.

5.2 Experimental setup:

In the prediction modelling with ANFIS for determination of surface roughness an experimental setup is needed. The experimental setup was set for the three machining parameter spindle speed (m/min), feed (mm/rev) and depth of cut (mm). The machining centre for End milling process will be vertical CNC milling centre with Al Ti Si N coated carbide four flute End mill Cutter Helix angle 45^{o} , 10mm (or 25mm) diameter. The material used for experimentation will be Böhler K340 of hardness 62 HRC and the chemical composition C, 1.10 %; Si, 0.90 %; Mn, 0.40%; Cr, 8.30 %; Mo,2.10 %; V, 0.50 %. The work piece size 100 mm × 80 mm × 40 mm will be used to generate the data of 64 sets. The surface roughness (Ra) will be measured with surface roughness tester. The surface roughness parameter was selected according to UNE-EN-ISO 4287:1999 standard and centre line average (CLA). The range of input machining parameter for the investigation will be, spindle speed (S) 75 – 150 m/ min, Feed (F) 0.02 – 0.06 (mm/rev) and depth of cut (D) 6 – 12 (mm).

A high-speed steel (HSS) / Carbide four-flute end milling cutter with a diameter of ¾ inch will be used in this experiment to machine material. Spindle speed, feed rate and depth of cut were selected as the machining parameters to analyze their effect on output cutting parameters. A total of 48 training sets will be used in the ANFIS method. Among them, the settings of spindle speed include eg. 750, 1000, 1250 and 1500 rpm; those of feed rate include 6, 12, 18 and 24 ipm; the depth of cut is set at 0.01, 0.03 and 0.05 in. Among the testing data for ANFIS, except for the different feed rate settings of 9, 15 and 21 ipm, the settings for the other parameters are the same as those used in the training sets. The value of output cutting parameters will be measured after milling according to the above machining conditions and then will be used as the training and testing data in ANFIS.

The similar type of prediction modelling will be performed with other tool steel materials used in industry such as Bohler K110, Bohler K340, DC 53, AISI 1040 die steel, SKD 11 and SKD 61. The effect of undesirable effects such as noise, vibration, temperature, power consumption and tool wear may be considered for prediction modelling. The work can be extended using material properties as in put parameter for global prediction model.

5.3 Work plan

The total duration proposed to complete research project is of 30 months.

First presentation (Progress report 1) – after 06 Months

1. Literature review
2. Mat lab learning
3. ANFIS implementation learning on Mat lab work bench
4. JJTU Course work (Theory and seminar) completion

Second presentation (Progress report 2) – after 12 months

1. Experimental set up
2. Define material and properties
3. Selection of input and output cutting parameters
4. Data collection
5. Selection of testing and training data after epochs
6. Using training data for ANFIS
7. Using testing data for ANFIS
8. Prepare prediction model using MET Lab.
9. Results and conclusion
10. Presenting the work in journal

Third presentation (Progress report 3) – after 18 months

1. Change the input and output cutting parameters for the above material
2. Collect data
3. Selection of testing and training data after epochs
4. Apply step 5 to 9 as above in presentation first
5. Presenting the work in journal

Fourth Presentation (Progress report 4)– after 24 months

Final submission of thesis will be after permission of supervisor and fulfilling the minimum requirements.